

What is claimed is:

- 1 1. A processor for reading instructions from a memory  
2 according to a program counter, the memory storing  
3 instructions in one-byte units, and for executing the read  
4 instructions,  
5 the program counter including a first program counter  
6 and a second program counter,  
7 the first program counter indicating a storage  
8 position of a processing packet in the memory, the  
9 processing packet being composed of an integer number of  
10 the one-byte units,  
11 the second program counter indicating a position of  
12 processing target instruction in the processing packet, the  
13 processing target instruction being an operation to be  
14 executed by the processor.
- 1 2. The processor of Claim 1, including a first program  
2 counter updating means and a second program counter  
3 updating means,  
4 the second program counter updating means  
5 incrementing a value of the second program counter in  
6 accordance with an amount of instructions that were  
7 executed in a preceding cycle and sending any carry  
8 generated in an incrementing to the first program counter  
9 updating means, and  
10 the first program counter updating means adding the  
11 carry received from the second program counter updating

12 means to the value of the first program counter.

1 3. The processor of Claim 2, further including:

2 program counter relative value extracting means for  
3 extracting, when an instruction being executed includes a  
4 program counter relative value that is based on an address  
5 of a first instruction executed in a present cycle, the  
6 program counter relative value; and

7 calculating means for adding the program counter  
8 relative value to the value of the first program counter  
9 and the value of the second program counter, and setting an  
10 addition result as the value of the first program counter  
11 and the value of the second program counter.

1 4. The processor of Claim 3,

2 wherein the calculating means includes a first  
3 calculating unit and a second calculating unit,

4 the second calculating unit adding the value of the  
5 second program counter and lower bits of the program  
6 counter relative value, setting a result of an addition as  
7 the value of the second program counter, and sending any  
8 carry generated in the addition to the first calculating  
9 unit,

10 the first calculating unit adding the value of the  
11 first program counter, upper bits of the program counter  
12 relative value, and any carry received from the second  
13 calculating unit, and setting a result of an addition as

14 the value of the first program counter.

1 5. The processor of Claim 3,

2 wherein the calculating means includes a first  
3 calculating unit and a second calculating unit,

4 the second calculating unit adding the value of the  
5 second program counter and lower bits of the program  
6 counter relative value without generating a carry, and  
7 setting a result of an addition as the value of the second  
8 program counter,

9 the first calculating unit adding the value of the  
10 first program counter and upper bits of the program counter  
11 relative value, and setting a result of an addition as the  
12 value of the first program counter.

1 6. The program counter of Claim 3,

2 wherein the calculating means adds the value of the  
3 first program counter and upper bits of the program counter  
4 relative value, sets a result of an addition as the value  
5 of the first program counter, and sets lower bits of the  
6 program counter relative value as the value of the second  
7 program counter.

1 7. The processor of Claim 3,

2 wherein the calculating means adds the program  
3 counter relative value and a value whose upper bits are the  
4 value of the first program counter and lower bits are the

5 value of the second program counter, and sets upper bits of  
6 a result of an addition as the value of the first program  
7 counter and lower bits of the result as the second program  
8 counter.

1 8. The processor of Claim 2, further including:

2 program counter relative value extracting means for  
3 extracting, when an executed instruction includes a program  
4 counter relative value that is based on an address of the  
5 executed instruction, the program counter relative value;

6 program counter amending means for amending the value  
7 of the first program counter and the value of the second  
8 program counter to indicate an address of the executed  
9 instruction; and

10 calculating means for adding the program counter  
11 relative value, the value of the first program counter, and  
12 the value of the second program counter, and setting a  
13 result of an addition as the value of the first program  
14 counter and the value of the second program counter.

1 9. The processor of Claim 2, further including:

2 program counter relative value calculating  
3 instruction decoding means for decoding a program counter  
4 relative value calculating instruction that performs an  
5 addition using a program counter relative value and one of

6 (a) a value of the program counter stored in a  
7 register, and

8 (b) the value of the first program counter and the  
9 value of the second program counter;  
10 calculating means for performing the addition  
11 indicated by the program counter relative value calculating  
12 instruction to generate an addition result; and  
13 program counter value updating means for storing the  
14 addition result in one of  
15 (a) the register, and  
16 (b) the first program counter and the second program  
17 counter.

1 10. The processor of Claim 1,  
2 wherein the first program counter indicates a memory  
3 address, the memory address being a storage position in the  
4 memory of a processing packet that is given by bit shifting  
5 the value in the first program counter by  $\log_2 n$  bits in a  
6 leftward direction,  $n$  being a length of a processing packet  
7 in bytes.

1 11. The processor of Claim 10, further including  
2 an instruction buffer for temporarily storing  
3 instructions; and  
4 instruction reading means for transferring  
5 instructions with a minimum transfer size of one one-byte  
6 unit from the memory to the instruction buffer, in  
7 accordance with available space in the instruction buffer  
8 but regardless of a size of a processing packet.

1 12. An instruction sequence optimizing apparatus, for  
2 generating optimized code from an instruction sequence,  
3 comprising:  
4 address assigning means for estimating a size of each  
5 instruction in the instruction sequence and assigning an  
6 address to each instruction, upper bits of each address  
7 indicating a memory address at which a processing packet is  
8 stored and lower bits of each address indicating a  
9 processing target instruction in the processing packet;  
10 label detecting means  
11 (1) for detecting a label, which should be resolved  
12 by an address of a specified instruction, from the  
13 instruction sequence, and obtaining the address of  
14 the specified instruction, and  
15 (2) for detecting a label, which should be resolved  
16 by a difference in addresses of two specified  
17 instructions, from the instruction sequence, and  
18 obtaining the addresses of the two specified  
19 instructions;  
20 program counter relative value calculating means for  
21 calculating, when a label which should be resolved by a  
22 difference in addresses of two specified instructions has  
23 been detected, a program counter relative value by  
24 subtracting an address of one of the two specified  
25 instructions from an address of another of the two  
26 specified instructions;

27           converting means  
 28           (1) for converting an instruction that has a label  
 29           that should be resolved by an address of a  
 30           specified instruction into an instruction with a  
 31           size that is based on a size of the address of the  
 32           specified instruction,  
 33           (2) for converting an instruction that has a label  
 34           that should be resolved by a difference in  
 35           addresses of two specified instructions into an  
 36           instruction with a size that is based on a size of  
 37           the program counter relative value calculated from  
 38           the addresses of the two specified instructions;  
 39           and  
 40           optimized code generating means for generating  
 41           optimized code by converting addresses of instructions in  
 42           accordance with the sizes of instructions after conversion  
 43           by the converting means.

1    13. The instruction sequence optimizing apparatus of Claim  
 2    12,  
 3           wherein the program counter relative value  
 4    calculating means includes a lower bit subtracting unit and  
 5    an upper bit subtracting unit,  
 6           the lower bit subtracting unit subtracting lower bits  
 7    of the address of the one of the two specified instructions  
 8    from lower bits of the address of the other of the two  
 9    specified instructions, for setting a result of a

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10 subtraction as lower bits of the program counter relative  
11 value, and sending any carry generated in the subtraction  
12 to the upper bit subtracting unit, and  
13 the upper bit subtracting unit subtracting upper bits  
14 of the address of one of the two specified instructions and  
15 any carry received from the lower bit subtracting unit from  
16 upper bits of the address of the other of the two specified  
17 instructions, and for setting a result of a subtraction as  
18 upper bits of the program counter relative value.

1 14. The instruction sequence optimizing apparatus of Claim  
2 12,

3 wherein the program counter relative value  
4 calculating means includes a lower bit subtracting unit and  
5 an upper bit subtracting unit,

6 the lower bit subtracting unit subtracting lower bits  
7 of the address of one of the two specified instructions  
8 from lower bits of the address of the other of the two  
9 specified instructions without generating a carry and  
10 setting a result of a subtraction as lower bits of the  
11 program counter relative value, and

12 the upper bit subtracting unit subtracting upper bits  
13 of the address of one of the two specified instructions  
14 from upper bits of the address of the other of the two  
15 specified instructions, and for setting a result of a  
16 subtraction as upper bits of the program counter relative  
17 value.



1 15. The instruction sequence optimizing apparatus of Claim  
2 12,

3 wherein the program counter relative value  
4 calculating means subtracts upper bits of an address of one  
5 of the two specified instructions from upper bits of an  
6 address of the other of the two specified instructions,  
7 sets a result of a subtraction as upper bits of the program  
8 counter relative value, and sets lower bits of the other of  
9 the two specified instructions as lower bits of the program  
10 counter relative value.

1 16. An assembler that generates relocatable code from an  
2 instruction sequence, each address of an instruction in the  
3 instruction sequence having upper bits that indicate a  
4 memory address at which a processing packet is stored and  
5 lower bits that indicate a position of processing target  
6 instruction that is included in the processing packet,

7 the assembler comprising:

8 label detecting means for detecting a label in the  
9 instruction sequence that should be resolved by a  
10 difference in addresses between two specified instructions,  
11 and obtaining the addresses of the two specified  
12 instructions;

13 program counter relative value calculating means for  
14 calculating a program counter relative value by subtracting  
15 an address of one of the two specified instructions from an

16 address of another of the two specified instructions; and  
17 replacing means for replacing the label with the  
18 program counter relative value calculated by the program  
19 counter relative value calculating means.

1 17. The assembler of Claim 16,  
2 wherein the program counter relative value  
3 calculating means includes a lower bit subtracting unit and  
4 an upper bit subtracting unit,  
5 the lower bit subtracting unit subtracting lower bits  
6 of the address of the one of the two specified instructions  
7 from lower bits of the address of the other of the two  
8 specified instructions, for setting a result of a  
9 subtraction as lower bits of the program counter relative  
10 value, and sending any carry generated in the subtraction  
11 to the upper bit subtracting unit, and  
12 the upper bit subtracting unit subtracting upper bits  
13 of the address of one of the two specified instructions and  
14 any carry received from the lower bit subtracting unit from  
15 upper bits of the address of the other of the two specified  
16 instructions, and for setting a result of a subtraction as  
17 upper bits of the program counter relative value.

1 18. The assembler of Claim 16,  
2 wherein the program counter relative value  
3 calculating means includes a lower bit subtracting unit and  
4 an upper bit subtracting unit,

5           the lower bit subtracting unit subtracting lower bits  
6 of the address of one of the two specified instructions  
7 from lower bits of the address of the other of the two  
8 specified instructions without generating a carry and  
9 setting a result of a subtraction as lower bits of the  
10 program counter relative value, and

11           the upper bit subtracting unit subtracting upper bits  
12 of the address of one of the two specified instructions  
13 from upper bits of the address of the other of the two  
14 specified instructions, and for setting a result of a  
15 subtraction as upper bits of the program counter relative  
16 value.

1   19. The assembler of Claim 16,

2           wherein the program counter relative value  
3 calculating means subtracts upper bits of an address of one  
4 of the two specified instructions from upper bits of an  
5 address of the other of the two specified instructions,  
6 sets a result of a subtraction as upper bits of the program  
7 counter relative value, and sets lower bits of the other of  
8 the two specified instructions as lower bits of the program  
9 counter relative value.

1   20. A linker that generates object code by combining  
2 relocatable code, each address of an instruction in the  
3 relocatable code having upper bits that indicate a memory  
4 address at which a processing packet is stored and lower

bits that indicate a position of processing target  
instruction that is included in the processing packet,  
the linker comprising:  
relocation information detecting means for detecting  
a label in the relocatable code that should be resolved by  
a difference in addresses between two specified  
instructions, and obtaining the addresses of the two  
specified instructions;  
program counter relative value calculating means for  
calculating a program counter relative value by subtracting  
an address of one of the two specified instructions from an  
address of another of the two specified instructions; and  
replacing means for replacing the label with the  
program counter relative value calculated by the program  
counter relative value calculating means.

21. The linker of Claim 20,  
wherein the program counter relative value  
calculating means includes a lower bit subtracting unit and  
an upper bit subtracting unit,  
the lower bit subtracting unit subtracting lower bits  
of the address of the one of the two specified instructions  
from lower bits of the address of the other of the two  
specified instructions, for setting a result of a  
subtraction as lower bits of the program counter relative  
value, and sending any carry generated in the subtraction  
to the upper bit subtracting unit, and

12 the upper bit subtracting unit subtracting upper bits  
13 of the address of one of the two specified instructions and  
14 any carry received from the lower bit subtracting unit from  
15 upper bits of the address of the other of the two specified  
16 instructions, and for setting a result of a subtraction as  
17 upper bits of the program counter relative value.

1 22. The linker of Claim 20,  
2 wherein the program counter relative value  
3 calculating means includes a lower bit subtracting unit and  
4 an upper bit subtracting unit,  
5 the lower bit subtracting unit subtracting lower bits  
6 of the address of one of the two specified instructions  
7 from lower bits of the address of the other of the two  
8 specified instructions without generating a carry and  
9 setting a result of a subtraction as lower bits of the  
10 program counter relative value, and  
11 the upper bit subtracting unit subtracting upper bits  
12 of the address of one of the two specified instructions  
13 from upper bits of the address of the other of the two  
14 specified instructions, and for setting a result of a  
15 subtraction as upper bits of the program counter relative  
16 value.

1 23. The linker of Claim 20,  
2 wherein the program counter relative value  
3 calculating means subtracts upper bits of an address of one

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4 of the two specified instructions from upper bits of an  
5 address of the other of the two specified instructions,  
6 sets a result of a subtraction as upper bits of the program  
7 counter relative value, and sets lower bits of the other of  
8 the two specified instructions as lower bits of the program  
9 counter relative value.

1 24. A disassembler that receives an indication of an  
2 address of an instruction in object code and outputs an  
3 assembler name of the instruction at the indicated address,  
4 each address of an instruction in the object code having  
5 upper bits that indicate a memory address at which a  
6 processing packet is stored and lower bits that indicate a  
7 position of processing target instruction that is included  
8 in the processing packet,

9 the disassembler comprising:

10 program counter relative value extracting means for  
11 extracting, when the indicated instruction includes a  
12 program counter relative value, the program counter  
13 relative value from the indicated instruction;

14 label addressing calculating means for adding an  
15 address of the indicated instruction to the extracted  
16 program counter relative value and setting an addition  
17 result as a label address;

18 storing means for storing a label name corresponding  
19 to each label address; and

20 searching means for searching the storing means for a

21 label name that corresponds to the calculated label address  
22 and outputting the corresponding label name.

1 25. The disassembler of Claim 24,  
2 wherein the label address calculating means includes  
3 a lower bit calculating unit and an upper bit calculating  
4 unit,  
5 the lower bit calculating unit for adding lower bits  
6 of the address of the indicated instruction and lower bits  
7 of the program counter relative value, setting a result of  
8 an addition as lower bits of a label address, and sending  
9 any carry generated by the addition to the upper bit  
10 calculating unit, and  
11 the upper bit calculating unit adding upper bits of  
12 the address of the indicated instruction, upper bits of the  
13 program counter relative value, and any carry received from  
14 the lower bit calculating unit, and setting a result of the  
15 an addition as upper bits of the label address.

1 26. The disassembler of Claim 24,  
2 wherein the label address calculating means includes  
3 a lower bit calculating unit and an upper bit calculating  
4 unit,  
5 the lower bit calculating unit adding lower bits of  
6 the address of the indicated instruction and lower bits of  
7 the program counter relative value without generating a  
8 carry, and setting a result of an addition as lower bits of

9 a label address, and  
10 the upper bit calculating unit adding upper bits of  
11 the address of the indicated instruction and upper bits of  
12 the program counter relative value, and setting a result of  
13 an addition as upper bits of the label address.

1 27. The disassembler of Claim 24, wherein  
2 the label address calculating means adds upper bits  
3 of the address of the indicated instruction and upper bits  
4 of the program counter relative value, sets a result of an  
5 addition as upper bits of the label address, and sets lower  
6 bits of the program counter relative value as lower bits of  
7 the label address.

1 28. A debugger that receives an indication of an address of  
2 an instruction in object code and replaces the instruction  
3 at the indicated address with a replacement instruction,  
4 each address of an instruction in the object code having  
5 upper bits that indicate a memory address at which a  
6 processing packet is stored and lower bits that indicate a  
7 position of processing target instruction that is included  
8 in the processing packet,

9 the debugger comprising:

10 processing packet reading means for reading a  
11 processing packet that is indicated by upper bits of the  
12 indicated address from the memory and writing the  
13 processing packet into an instruction buffer;



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14 instruction writing means for writing the replacement  
15 instruction into the processing packet in the instruction  
16 buffer over an instruction that is indicated by the lower  
17 bits of the indicated address; and

18 processing packet writing means for writing the  
19 processing packet in the instruction buffer back into the  
20 memory after the replacement instruction has been written.

1 29. A compiler that generates an instruction sequence from  
2 source code,

3 the compiler generating a program counter relative  
4 value calculating instruction that is executed by a  
5 processor, the program counter relative value calculating  
6 instruction being an instruction that performs a  
7 calculation using a first value and a program counter  
8 relative value and uses a result of the calculation to  
9 update the first value, the first value being one of

10 (a) a value of a program counter stored in a  
11 register, and

12 (b) the value stored in a program counter of the  
13 processor,

14 wherein upper bits of the first value indicate a  
15 memory address at which a processing packet is stored, and  
16 lower bits of the first value of the program counter  
17 indicate a processing target instruction that is included  
18 in the processing packet.

1 30. The compiler of Claim 29,  
2 wherein the processor includes a lower bit  
3 calculating unit and an upper bit calculating unit,  
4 the program counter relative value calculating  
5 instruction having the lower bit calculating unit perform a  
6 lower bit calculation and the upper bit calculating unit  
7 perform an upper bit calculation,  
8 the lower bit calculation being an addition using  
9 lower bits of the first value and lower bits of the value  
10 of the program counter relative value, where a result of  
11 the lower bit calculation is set as the lower bits of the  
12 first value and any generated carry is sent to the upper  
13 bit calculating unit, and  
14 the upper bit calculation being an addition using  
15 upper bits of the first value, upper bits of the value of  
16 the program counter relative value and any carry received  
17 from the lower bit calculating unit, where a result of the  
18 upper bit calculation is set as the upper bits of the first  
19 value.

1 31. The compiler of Claim 29,  
2 wherein the processor includes a lower bit  
3 calculating unit and an upper bit calculating unit,  
4 the program counter relative value calculating  
5 instruction having the lower bit calculating unit perform a  
6 lower bit calculation and the upper bit calculating unit  
7 perform an upper bit calculation,

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8           the lower bit calculation being an addition using  
9   lower bits of the first value and lower bits of the value  
10   of the program counter relative value that does not  
11   generate a carry, where a result of the lower bit  
12   calculation is set as the lower bits of the first value,  
13   and

14           the upper bit calculation being a calculation using  
15   upper bits of the first value and upper bits of the value  
16   of the program counter relative value, where a result of  
17   the upper bit calculation is set as the upper bits of the  
18   first value.

1   32. The compiler of Claim 29,

2           wherein the processor includes an upper bit  
3   calculating unit,

4           the program counter relative value calculating  
5   instruction having the upper bit calculating unit perform  
6   an upper bit calculation and setting lower bits of the  
7   program counter relative value as lower bits of the first  
8   value, and

9           the upper bit calculation being an addition using  
10   upper bits of the first value and upper bits of the value  
11   of the program counter relative value, where a result of  
12   the upper bit calculation is set as the upper bits of the  
13   first value.

1   33. A computer-readable recording medium storing an

2 instruction sequence optimizing program that generates  
 3 optimized code from an instruction sequence, the  
 4 instruction sequence optimizing program including:  
 5 an address assigning step for estimating a size of  
 6 each instruction in the instruction sequence and assigning  
 7 an address to each instruction, upper bits of each address  
 8 indicating a memory address at which a processing packet is  
 9 stored and lower bits of each address indicating a  
 10 processing target instruction in the processing packet;  
 11 a label detecting step (1) for detecting a label,  
 12 which should be resolved by an address of a specified  
 13 instruction, from the instruction sequence, and obtaining  
 14 the address of the specified instruction, and  
 15 (2) for detecting a label, which should be resolved  
 16 by a difference in addresses of two specified  
 17 instructions, from the instruction sequence, and  
 18 obtaining the addresses of the two specified  
 19 instructions;  
 20 a program counter relative value calculating step for  
 21 calculating, when a label which should be resolved by a  
 22 difference in addresses of two specified instructions has  
 23 been detected, a program counter relative value by  
 24 subtracting an address of one of the two specified  
 25 instructions from an address of another of the two  
 26 specified instructions;  
 27 a converting step  
 28 (1) for converting an instruction that has a label

29 that should be resolved by an address of a specified  
 30 instruction into an instruction with a size that is based  
 31 on a size of the address of the specified instruction,

32 (2) for converting an instruction that has a label  
 33 that should be resolved by a difference in  
 34 addresses of two specified instructions into an  
 35 instruction with a size that is based on a size of  
 36 the program counter relative value calculated from  
 37 the addresses of the two specified instructions;  
 38 and

39 an optimized code generating step for generating  
 40 optimized code by converting addresses of instructions in  
 41 accordance with the sizes of instructions after conversion  
 42 in the converting step.

1 34. The computer-readable recording medium of Claim 33,  
 2 wherein the program counter relative value  
 3 calculating step includes a lower bit subtracting substep  
 4 and an upper bit subtracting substep,  
 5 the lower bit subtracting substep subtracting lower  
 6 bits of the address of the one of the two specified  
 7 instructions from lower bits of the address of the other of  
 8 the two specified instructions, for setting a result of a  
 9 subtraction as lower bits of the program counter relative  
 10 value, and sending any carry generated in the subtraction  
 11 to the upper bit subtracting substep, and  
 12 the upper bit subtracting substep subtracting upper

13 bits of the address of one of the two specified  
14 instructions and any carry received from the lower bit  
15 subtracting substep from upper bits of the address of the  
16 other of the two specified instructions, and for setting a  
17 result of a subtraction as upper bits of the program  
18 counter relative value.

1 35. The computer-readable recording medium of Claim 33,  
2 wherein the program counter relative value  
3 calculating step includes a lower bit subtracting substep  
4 and an upper bit subtracting substep,  
5 the lower bit subtracting substep subtracting lower  
6 bits of the address of one of the two specified  
7 instructions from lower bits of the address of the other of  
8 the two specified instructions without generating a carry  
9 and setting a result of a subtraction as lower bits of the  
10 program counter relative value, and  
11 the upper bit subtracting substep subtracting upper  
12 bits of the address of one of the two specified  
13 instructions from upper bits of the address of the other of  
14 the two specified instructions, and for setting a result of  
15 a subtraction as upper bits of the program counter relative  
16 value.

1 36. The computer-readable recording medium of Claim 33,  
2 wherein the program counter relative value  
3 calculating step subtracts upper bits of an address of one

4 of the two specified instructions from upper bits of an  
5 address of the other of the two specified instructions,  
6 sets a result of a subtraction as upper bits of the program  
7 counter relative value, and sets lower bits of the other of  
8 the two specified instructions as lower bits of the program  
9 counter relative value.

1 37. A computer-readable recording medium storing an  
2 assembler program that generates relocatable code from  
3 optimized code that have been generated from an instruction  
4 sequence, each address of an instruction in the optimized  
5 code having upper bits that indicate a memory address at  
6 which a processing packet is stored and lower bits that  
7 indicate a position of processing target instruction that  
8 is included in the processing packet,

9 the assembler program comprising:

10 a label detecting step for detecting a label in the  
11 instruction sequence that should be resolved by a  
12 difference in addresses between two specified instructions,  
13 and obtaining the addresses of the two specified  
14 instructions;

15 a program counter relative value calculating step for  
16 calculating a program counter relative value by subtracting  
17 an address of one of the two specified instructions from an  
18 address of another of the two specified instructions; and

19 a replacing step for replacing the label with the  
20 program counter relative value calculated by the program

21 counter relative value calculating step.

1 38. The computer-readable recording medium of Claim 37,  
2 wherein the program counter relative value  
3 calculating step includes a lower bit subtracting substep  
4 and an upper bit subtracting substep,  
5 the lower bit subtracting substep subtracting lower  
6 bits of the address of the one of the two specified  
7 instructions from lower bits of the address of the other of  
8 the two specified instructions, for setting a result of a  
9 subtraction as lower bits of the program counter relative  
10 value, and sending any carry generated in the subtraction  
11 to the upper bit subtracting substep, and  
12 the upper bit subtracting substep subtracting upper  
13 bits of the address of one of the two specified  
14 instructions and any carry received from the lower bit  
15 subtracting substep from upper bits of the address of the  
16 other of the two specified instructions, and for setting a  
17 result of a subtraction as upper bits of the program  
18 counter relative value.

1 39. The computer-readable recording medium of Claim 37,  
2 wherein the program counter relative value  
3 calculating step includes a lower bit subtracting substep  
4 and an upper bit subtracting substep,  
5 the lower bit subtracting substep subtracting lower  
6 bits of the address of one of the two specified



7 instructions from lower bits of the address of the other of  
8 the two specified instructions without generating a carry  
9 and setting a result of a subtraction as lower bits of the  
10 program counter relative value, and  
11 the upper bit subtracting substep subtracting upper  
12 bits of the address of one of the two specified  
13 instructions from upper bits of the address of the other of  
14 the two specified instructions, and for setting a result of  
15 a subtraction as upper bits of the program counter relative  
16 value.

1 40. The computer-readable recording medium of Claim 37,  
2 wherein the program counter relative value  
3 calculating step subtracts upper bits of an address of one  
4 of the two specified instructions from upper bits of an  
5 address of the other of the two specified instructions,  
6 sets a result of a subtraction as upper bits of the program  
7 counter relative value, and sets lower bits of the other of  
8 the two specified instructions as lower bits of the program  
9 counter relative value.

1 41. A computer-readable recording medium storing a linker  
2 program that generates object code from relocatable code  
3 that has been generated from an instruction sequence, each  
4 address of an instruction in the optimized code having  
5 upper bits that indicate a memory address at which a  
6 processing packet is stored and lower bits that indicate a

7 position of processing target instruction that is included  
8 in the processing packet,  
9 the linker program comprising:  
10 a relocation information detecting step for detecting  
11 a label in the relocatable code that should be resolved by  
12 a difference in addresses between two specified  
13 instructions, and obtaining the addresses of the two  
14 specified instructions;  
15 a program counter relative value calculating step for  
16 calculating a program counter relative value by subtracting  
17 an address of one of the two specified instructions from an  
18 address of another of the two specified instructions; and  
19 a replacing step for replacing the label with the  
20 program counter relative value calculated by the program  
21 counter relative value calculating step.

1 42. The computer-readable recording medium of Claim 41,  
2 wherein the program counter relative value  
3 calculating step includes a lower bit subtracting substep  
4 and an upper bit subtracting substep,  
5 the lower bit subtracting substep subtracting lower  
6 bits of the address of the one of the two specified  
7 instructions from lower bits of the address of the other of  
8 the two specified instructions, for setting a result of a  
9 subtraction as lower bits of the program counter relative  
10 value, and sending any carry generated in the subtraction  
11 to the upper bit subtracting substep, and

12           the upper bit subtracting substep subtracting upper  
13 bits of the address of one of the two specified  
14 instructions and any carry received from the lower bit  
15 subtracting substep from upper bits of the address of the  
16 other of the two specified instructions, and for setting a  
17 result of a subtraction as upper bits of the program  
18 counter relative value.

1     43. The computer-readable recording medium of Claim 41,  
2           wherein the program counter relative value  
3 calculating step includes a lower bit subtracting substep  
4 and an upper bit subtracting substep,  
5           the lower bit subtracting substep subtracting lower  
6 bits of the address of one of the two specified  
7 instructions from lower bits of the address of the other of  
8 the two specified instructions without generating a carry  
9 and setting a result of a subtraction as lower bits of the  
10 program counter relative value, and  
11           the upper bit subtracting substep subtracting upper  
12 bits of the address of one of the two specified  
13 instructions from upper bits of the address of the other of  
14 the two specified instructions, and for setting a result of  
15 a subtraction as upper bits of the program counter relative  
16 value.

1     44. The computer-readable recording medium of Claim 41,  
2           wherein the program counter relative value

3 calculating step subtracts upper bits of an address of one  
4 of the two specified instructions from upper bits of an  
5 address of the other of the two specified instructions,  
6 sets a result of a subtraction as upper bits of the program  
7 counter relative value, and sets lower bits of the other of  
8 the two specified instructions as lower bits of the program  
9 counter relative value.

1 45. A computer-readable recording medium storing a compiler  
2 program that generates an instruction sequence from source  
3 code,

4 the compiler program generating a program counter  
5 relative value calculating instruction that is executed by  
6 a processor, the program counter relative value calculating  
7 instruction being an instruction that performs a  
8 calculation using a first value and a program counter  
9 relative value and uses a result of the calculation to  
10 update the first value, the first value being one of

11 (a) a value of a program counter stored in a  
12 register, and

13 (b) the value stored in a program counter of the  
14 processor,

15 wherein upper bits of the first value indicate a  
16 memory address at which a processing packet is stored, and  
17 lower bits of the first value of the program counter  
18 indicate a processing target instruction that is included  
19 in the processing packet.

1 46. The computer-readable recording medium of Claim 45,  
 2 wherein the processor includes a lower bit  
 3 calculating unit and an upper bit calculating unit,  
 4 the program counter relative value calculating  
 5 instruction having the lower bit calculating unit perform a  
 6 lower bit calculation and the upper bit calculating unit  
 7 perform an upper bit calculation,  
 8 the lower bit calculation being an addition using  
 9 lower bits of the first value and lower bits of the value  
 10 of the program counter relative value, where a result of  
 11 the lower bit calculation is set as the lower bits of the  
 12 first value and any generated carry is sent to the upper  
 13 bit calculating unit, and  
 14 the upper bit calculation being an addition using  
 15 upper bits of the first value, upper bits of the value of  
 16 the program counter relative value and any carry received  
 17 from the lower bit calculating unit, where a result of the  
 18 upper bit calculation is set as the upper bits of the first  
 19 value.

1 47. The computer-readable recording medium of Claim 45,  
 2 wherein the processor includes a lower bit  
 3 calculating unit and an upper bit calculating unit,  
 4 the program counter relative value calculating  
 5 instruction having the lower bit calculating unit perform a  
 6 lower bit calculation and the upper bit calculating unit

7 perform an upper bit calculation,  
8 the lower bit calculation being an addition using  
9 lower bits of the first value and lower bits of the value  
10 of the program counter relative value that does not  
11 generate a carry, where a result of the lower bit  
12 calculation is set as the lower bits of the first value,  
13 and  
14 the upper bit calculation being a calculation using  
15 upper bits of the first value and upper bits of the value  
16 of the program counter relative value, where a result of  
17 the upper bit calculation is set as the upper bits of the  
18 first value.

1 48. The computer-readable recording medium of Claim 45,  
2 wherein the processor includes an upper bit  
3 calculating unit,  
4 the program counter relative value calculating  
5 instruction having the upper bit calculating unit perform  
6 an upper bit calculation and setting lower bits of the  
7 program counter relative value as lower bits of the first  
8 value, and  
9 the upper bit calculation being an addition using  
10 upper bits of the first value and upper bits of the value  
11 of the program counter relative value, where a result of  
12 the upper bit calculation is set as the upper bits of the  
13 first value.